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How Does China's New Rural Pension Scheme Affect Agricultural Production?

Xing Ji [1], Jingwen Xu [2] and Hongxiao Zhang [1,*]

[1] College of Economics and Management, Nanjing Forestry University, Nanjing 210037, China; jixing@njfu.edu.cn
[2] College of Finance and Economics, Wuxi Institute of Technology, Wuxi 214121, China; xujingwen@njfu.edu.cn
* Correspondence: njhxzh@njfu.edu.cn

Abstract: This study examines the spillover effects of China's New Rural Pension Scheme (NRPS) implemented in 2009 as a cash transfer program for agricultural production. Based on the data collected by the China Health and Retirement Longitudinal Survey (CHARLS) in four periods (2011, 2013, 2015 and 2018), we employ Seemingly Unrelated Regression to explore how China's NRPS affects agricultural production. Our findings show that NRPS pensions reduce household operating areas by 1.99 mu and agricultural investment by 1150 yuan, while increasing the labor time of their own agricultural production by 168 h, and farmers in the payment period have a similar impact. This finding is still reliable after a series of robustness tests. Gender heterogeneity analysis indicates that male participation in NRPS is more likely to reduce the actual operating area and increase the labor input of the family, while female participation in NRPS is more likely to reduce the agricultural capital input of the family. Moreover, the in-depth study of agricultural performance shows that the implementation of NRPS helps increase the average output value per mu by 700 yuan and technical efficiency by 0.2%, although this is at the cost of declining labor productivity. This study links the joint decision-making of agricultural production factor inputs with pension schemes and contributes to the development of relevant research, which may provide policy implications for how cash transfer schemes affect agricultural production and agricultural performance in other countries.

Keywords: new rural pension scheme; agricultural production; China; seemingly unrelated regression

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1. Introduction

As the world's second-largest economy, China is experiencing unprecedented demographic transition and a rapid aging process. China's Seventh National Population Census (http://www.stats.gov.cn/tjsj/pcsj/rkpc/d7c/202111/P020211126523667366751.pdf (accessed on 15 June 2022)) data show that there were only 42.65 million people aged 60 and above in 1953, accounting for 7.32% of the total population. However, by 2021, the population aged 60 and above reached 264 million, accounting for 18.7% of the total population. According to the "National Bulletin on Aging Development in 2020" issued by the aging health department of the National Health Commission, the proportion of the rural elderly population aged 60 and above in the total rural population is 23.81%, which is 7.99% higher than that of the urban elderly population aged 60 and above in the total urban population. Thus, the aging level in rural areas is significantly higher than that in urban areas. With the rapid aging of population and the non-agricultural transfer of young labor, the age structure of the agricultural labor force is undergoing a major change, and the aging of the agricultural labor force is an inevitable trend in the process of China's

economic development. This not only brings great challenges to agricultural production, but also increases the pressure on the Chinese government's pension system.

In order to achieve the old-age well-being of rural residents and improve the rural old-age security system, the Chinese government launched the NRPS and implemented it in rural areas in 2009. By the end of 2012, the NRPS covered all county-level administrative regions of the country, with a total number of 480 million insured people nationwide, making it the pension project with the largest population in the world. The NRPS policy stipulates that rural residents over the age of 16 can voluntarily choose to participate in the NRPS, and the insured should pay at least 15 years of insurance costs before the age of 60. Rural residents aged between 45 and 60 during the implementation of the NRPS must pay insurance until the age of 60 before they can receive their pension. The elderly who already reached the age of 60 can receive pensions directly without paying any fees, but their children who fulfill the plan requirements must participate in the NRPS. In the early stage of the policy, the individual payment standard was set to five levels of CNY 100–500 per year and, since 2014, the basic payment standard was set to twelve levels of CNY 100–2000 per year. The basic pension of insured farmers is fully invested by state finance, and local governments provide payment subsidies to the insured farmers. The NRPS pension is now the most important source of income for elderly families [1].

Existing literature focused on the benefits of the NRPS within the family, including the benefits that it brings to the elderly [2,3], the intergenerational transmission benefits for other members of the family [4,5], and the overall economic welfare of the family [6,7]; however, the possible agricultural production effects of NRPS are ignored. According to economic theory, non-labor income, including pension, donations, and government transfer, will change the allocation decision of household production factors [8]. However, so far, little research investigated the initial impact of NRPS on land-leasing behavior [9], labor supply for the elderly [10], and agricultural investment expenditure [6]. Such literature fails to accurately expound the theoretical relationship between the NRPS and household agricultural production behavior. More importantly, the allocation decisions of various agricultural production factors in the family are interrelated [11]; this means that separating the impact of the NRPS into single factor inputs inevitably leads to the deviation of the research results from reality.

To quantitatively evaluate the agricultural production effect of the NRPS, we used data from the CHARLS in 2011, 2013, 2015 and 2018, employed Seemingly Unrelated Regression (SUR) to examine the impact of NRPS on the joint decision-making of household agricultural operating area, labor input, and capital investment, and used RDD–DID to test robustness. Due to the possible differences in preference and use of pensions between elderly men and women, we then conducted a heterogeneous analysis of the gender differences in the agricultural production effect of pensions. In addition, based on the "Structure–Conduct–Performance" analysis paradigm, we further evaluated the influence of the NRPS on agricultural productivity, including labor productivity, land productivity, and technical efficiency.

Our findings demonstrate that the NRPS generally reduces the actual agricultural operating area of insured households, increases the input of agricultural production labor, and reduces agricultural capital investment. As for the gender of the insured, the participation of elderly men in the NRPS has a greater impact on reducing the actual operating area of the family and increasing labor input, and the participation of elderly women in the NRPS has a greater impact on reducing the investment of family agricultural production funds. In addition, pensions significantly reduce labor productivity and increase land productivity and technical efficiency. The above results provide evidence that the NRPS has changed China's previous allocation of agricultural production factors and production efficiency.

The remainder of the paper is organized as follows. Section 2 presents the literature review and Section 3 presents the theoretical framework and theoretical clues based on the previous literature. Section 4 introduces the data, variables, and estimation strategy.

Section 5 reports the empirical results. Finally, Section 6 summarizes the conclusions and provides relevant recommendations.

2. Literature Review

The NRPS is a large cash transfer program and is closely related to agricultural production activities. To explain the potential mechanism and quantitatively evaluate its impact on agricultural production, in this section, we review the family welfare effect of social pension and the agricultural production effect of cash transfer payment. A detailed flow diagram is shown in Figure 1.

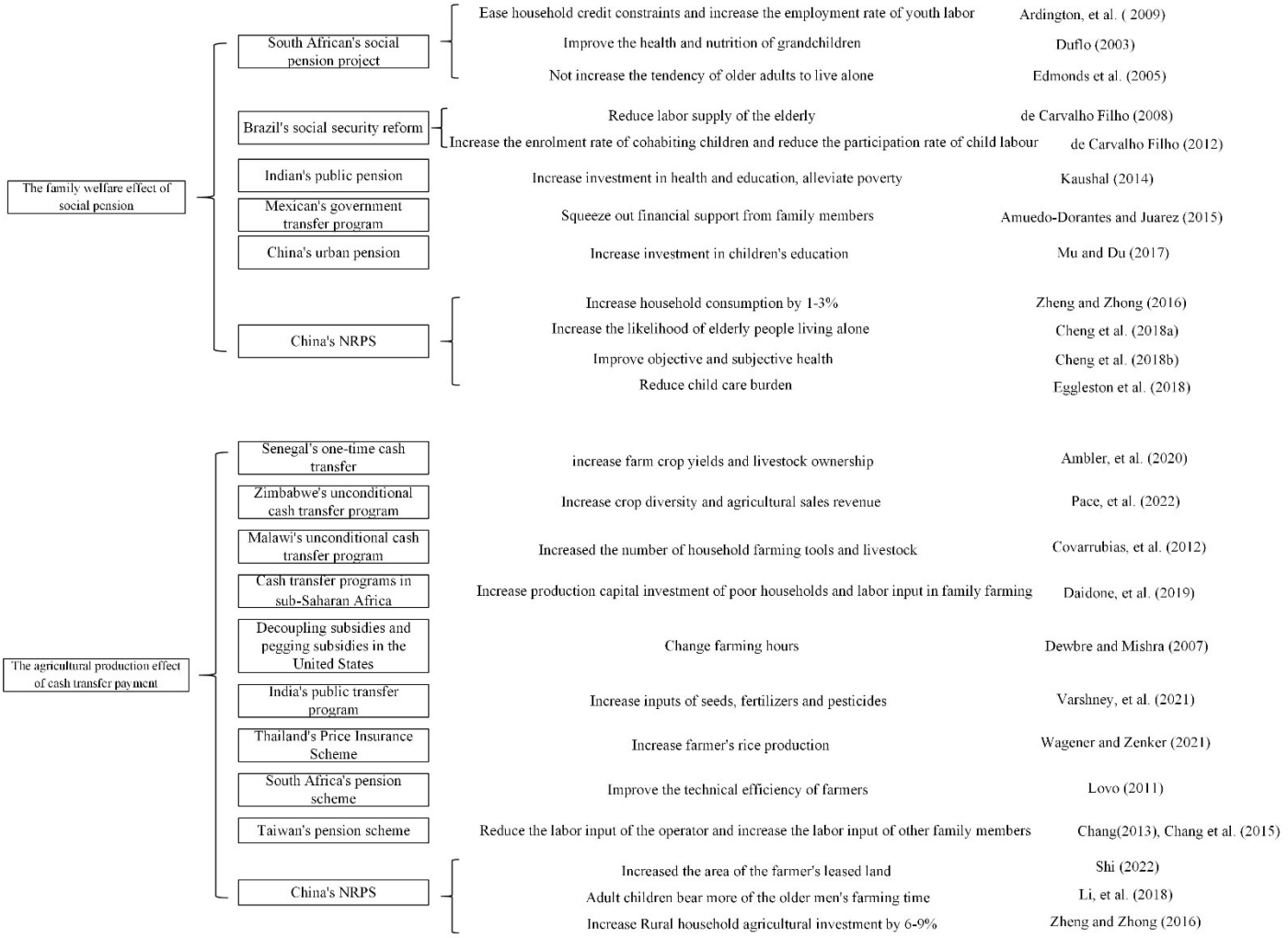


Figure 1. Flow diagram of literature review [1–4,6,12–29].

2.1. The Family Welfare Effect of Social Pension

In the 1990s, the amount of cash transfer of the South African social pension program was about twice the median rural per capita income. Pensions could alleviate household credit constraints and childcare constraints and increase the employment rate of young and middle-aged labors [12]. Elderly women receiving pensions saw a significant improvement in the health and nutritional status of their granddaughters [13]. Economists believe that living arrangements are also an important part of welfare. However, Edmonds found no evidence that pension income contributes to an increase in the tendency of the elderly to live alone, which possibly results from the slow development of the market for goods and services consumed by households in South Africa, and they only found that pensions could change the allocation of women's labor in households [14]. Moreover,

the income and welfare of the elderly brought about by social security reform in Brazil reduced the labor supply of the elderly [15], significantly increasing the enrolment rate of cohabiting children, especially girls, while reducing the participation rate of boys in child labor [30]. In India, the public pension significantly increases household expenditure, alleviates poverty, and has certain health effects. It is observed that families invest most of their pensions in health care and education [16]. The government transfer payment program for the elderly in Mexico could crowd out the economic support of 37% of other family members, so the welfare effect of the program is weakened by the response of family members [17].

Studies on China found that urban pension incomes significantly increased investment in urban children's education [18], and the decline in the replacement rate of urban pensions increased the savings rates of urban households, which led to a reduction in human capital investment represented by family education and medical expenditure [31]. In 2009, the Chinese government launched the pilot and promotion of the NRPS, covering 2853 county-level administrative regions across the country, with 480 million people insured at the end of 2012. Zheng found that rural household consumption in NRPS pilot counties increased by 1–3%, especially for poor households [6]. Cheng pointed out that each doubling of the NRPS pension leads to an increase of 4.1% in the possibility of the elderly living independently, and the effect is even greater for the elderly with strong self-care ability [19]; however, whether the NRPS affects the welfare of the elderly through living arrangements requires further discussion. Using CLHLS data and a panel fixed-effect model based on the instrumental variable method, Cheng confirmed that the NRPS can help improve the nutritional intake of the rural elderly, increase medical expenditure, informal care and leisure activities, and enhance self-economic status cognition, thus having a positive effect on objective health and subjective health status [2]. Shu employed the instrumental variable method to confirm that the NRPS pension significantly increased the possibility of retirement and reduced labor supply for the elderly in rural China [32]. Further, Huang took advantage of the quasi-natural experimental characteristics promoted by the NRPS, county by county, and found that pension income increased household food expenditure, reduced labor supply, improved health status and reduced mortality [7].

In addition, some literature observed the transfer effect of NRPS pensions within families: Eggleston pointed out that the monetary support of the NRPS reduced the burden of offspring care or postponed the time for the elderly to receive care (70 or 80 years old), thus pensions provided better living security for the elderly and provided children with more career choices and freedom to migrate to cities [3]. The measurement results showed that the NRPS increased the likelihood of non-agricultural employment of adult children by more than 20 percentage points. Li found that the NRPS increased the care of older men for grandchildren, reduced the dependence of older women on their offspring, and significantly reduced the probability of their children going out to work [4]. Shi used regression discontinuity design to confirm that although the NRPS increased the possibility of migration of adult children and relaxed credit constraints, the time spent on grandchild care and paid work by the elderly did not change with pensions, and NRPS had no significant impact on household consumption or welfare of the elderly [33]. Tang paid attention to the spillover effects of the NRPS on human capital investment and found that pensions significantly increased the education expenditure on adolescents aged 0 to 16 in the family, especially for girls and rich provinces [5].

However, there are some studies reporting opposing views. Lei pointed out that the coverage rate and income substitution rate of the NRPS were too low to effectively guarantee the rural elderly, which ultimately violated the policy objectives of the NRPS [34]. Tao argued that most farmers who participated in the NRPS chose the lowest payment standard, which resulted in low pension incomes and the inability to guarantee the basic life of the rural elderly [35]. Ning demonstrated that the NRPS significantly increased the

total working hours of pensioners, so it may not improve the welfare of the elderly, especially those with poor health [36]. Hua found that the amounts of NRPS subsidies were low, and participation in the NRPS only reduced the working hours of people aged 50–59. Only when both elderly parents received pensions, could adult children be encouraged to go elsewhere for employment [10].

2.2. The Agricultural Production Effect of Cash Transfer Payment

Most literature examined the agricultural production effect of cash transfer programs in Africa. Household survey data from Senegal showed that one-time cash transfer increased farm crop yields and livestock ownership [20]. Zimbabwe's unconditional cash transfer scheme increased household agricultural activities, crop diversity, and agricultural sales revenue [21]. The unconditional cash transfer project launched by the Malawi government in 2006 led to an increase in the number of household agricultural production tools and livestock [22], helping families with extreme poverty allocate more time to agricultural production, and significantly increasing the types of agricultural production [37]. The Kenyan government's cash transfer payments for orphans and vulnerable children had a similar productive effect [38]. An unconditional cash transfer for poor and vulnerable families in Lesotho increased agricultural output, possibly through changing liquidity constraints and risk preferences [39]; Lesotho's children's subsidy plan benefited farmers with productive potential and improved the farm profitability of these farmers [40]. The cash transfer programs in sub-Saharan Africa increased the production capital investment of poor households and household agricultural labor input, and changed farmers' risk attitudes [23].

Scholars also conducted many relevant studies on other countries. The United States decoupling subsidies reduced farming hours of farm operators, while the hook subsidies significantly increased farming hours [24]. American government transfer payments to the agricultural sector attracted farmers to increase agricultural labor inputs and reduced non-agricultural labor participation [41]. The public transfer scheme implemented by the Indian government under the COVID-19 pandemic increased farmer investment in seeds, fertilizers, and pesticides, which is of great significance in alleviating credit constraints and increasing modern factor inputs [25]. The Price Insurance Scheme (PIS) implemented by the Thai government, but abandoned after only two years, was a decoupling subsidy policy, which increased farmers' rice production and supported farmers to engage in off-farm employment activities [26].

As a type of cash transfer payment project, the social pension received increasing attention in terms of its the agricultural production effect. The South African pension scheme improved the technical efficiency of farmers [27]. Chang used the data from 465 dairy farms in Taiwan and the Treatment Effect Model, and found that pensions reduced the labor input of operators, but increased the labor input of other family members; furthermore, the pension had no significant impact on the number of employed labor, ultimately reducing the scale of the farm and the output value of each cow [28,29]. In rural China, the results for the Regression Discontinuity Design confirmed that access to pensions greatly increased the area of land leased by farmers [1]. Some scholars believe that the NRPS reduced farming time for older men and increased farming time for adult children [4]. Shu pointed out that even if the NRPS pension income was much lower than the minimum cost of living, it drastically reduced the employment of older women and their own agricultural labor supply [32]. Further evidence showed that after being designated as NRPS pilot counties, rural household agricultural investment increased by 6–9%; this mainly included the increase in liquid production investment, such as seeds, pesticides, and fertilizers [6].

3. Theoretical Framework

3.1. NRPS and Farmland Operating Area

For Chinese farmers, land is a means of production that can continuously generate operating income or property income, and has the functions of saving and living security [42]. The NRPS provides local subsidies and national subsidies of 55 yuan per month for farmers over the age of 60 (http://www.gov.cn/zwgk/2009-09/04/content_1409216.htm (accessed on 18 June 2022)), which brings a stable cash income flow to the elderly. According to price conditions at the time of writing, the annual subsidy amount is approximately equivalent to the purchasing power of 250 kg of rice. FAO defines hunger as a calorie intake less than 1800 kcal/person/day, so the NRPS subsidies do meet the minimum requirements for maintaining individual living and production conditions after conversion [43]. Therefore, the NRPS helps realize the substitution of "institutional guarantee" for "land guarantee" [44]; reduce farmer dependence on land; reduce the land transfer rent of farmer willingness; increase the probability of farmers renting out land; stimulate the development of the local farmland transfer market to a certain extent; reduce transaction costs in the process of farmland transfer; and, thus, reduce the actual operating area of farmers [45]. If NRPS pensions are used to support non-agricultural employment and entrepreneurial investment of family members, the family agricultural labor force will be squeezed, resulting in the inability of the elderly to operate agriculture independently and a reduction in the actual operating area. At the same time, if the NRPS causes the elderly to spend more time caring for their grandchildren, it may also promote farmers to rent out land, because the time spent by the elderly caring for their grandchildren occupies their time for farm work [4]. However, the NRPS was shown to improve the health of the elderly [2], which makes it more likely for them to retain and cultivate their land and even expand their operating area. Moreover, if the NRPS leads to a reduction in the supply of off-farm labor for the elderly, they will have more time to do farm work [46].

3.2. NRPS and Agricultural Labor Allocation

The impact of pensions on the input of household agricultural production labor includes the "income effect" and the "substitution effect". On the one hand, pension which belongs to non-labor income brings farmers the illusion of improving labor productivity. That is, the income obtained by paying the same working hours increases, causing individuals to relax budget constraints, increase the demand for leisure time, and reduce labor supply, namely the "income effect" of pensions [36,47]. On the other hand, the pension helps increase the investment of insured persons and their family members in human capital, such as education and health care, thereby improving labor productivity and resulting in an increase in the opportunity cost per unit time (that is, an increase in the cost of leisure time allocation), a reduction in farmer demands for leisure time, and an increase in labor supply; this is named the "substitution effect" of pensions [48,49]. It should be noted, however, that the above inference does not consider the difference between agricultural and non-agricultural labor inputs, and the impact of pensions on agricultural labor input depends on whether the above two effects influence agricultural or non-agricultural labor times.

Rational households in rural China usually diversify their income sources through labor migration to avoid the potential risks of traditional agricultural production. To a certain extent, the NRPS pension inhibits labor migration behavior based on risk aversion [4]. However, at the same time, receiving pensions can reduce the dependence of the elderly on adult children and allow them to care better for their grandchildren, thereby encouraging young adults to migrate and engage in non-agricultural work [3,50], and further adjusting the input of family agricultural labor.

3.3. NRPS and Agricultural Capital Investment

The Life-Cycle Model proposed by Modigliani believes that retirement will systematically change the income status of individuals, so rational-economic people will make intertemporal decisions on investment, consumption, and savings; that is, to achieve consumption smoothing and utility maximization of the whole life cycle through savings before retirement [51]. Theoretically, the NRPS pension increases the expected income of individuals after retirement, and the rational insured will reduce preventive savings before retirement and increase investment in agricultural production. However, imperfect social security may also limit the ability of families to consume smoothly across time and space, so families will take a series of measures to prevent risks before receiving pension income, including reducing productive investment and increasing savings [21,52].

Liquidity constraints and credit constraints are usually considered to be the major factors restricting productive investment and income-generating activities of rural households [53]. These restrictions can be overcome after the elderly receive pensions since NRPS belongs to a cash transfer program that changes the total wealth of rural households. Moreover, Schwab noted that insured farmers were more willing to engage in higher-risk and more valuable production [54]. There are, in fact, natural and market risks in agricultural production. NRPS pensions may influence family agricultural investment decisions by changing the risk preferences of the elderly [55].

It should be noted that under the condition that children are separated from the elderly, in light of the neoclassical economic model of pensions and children's economic support constructed by Becker [56], pensions will crowd out children's economic support for the elderly [17]. However, if pensions improve the economic independence of the elderly and increase the intergenerational contributions toward grandchild care, pensions also have the "crowding-in" effect of economic support for children [57–60], which has an uncertain impact on household agricultural investment.

3.4. NRPS and Joint Decision of Input of Various Agricultural Production Factors

Existing studies found linkages between various production factors. Ji pointed out that labor migration in rural areas has a significant impact on the rent of rural land transfer in China [61]. A possible explanation is that labor migration causes the loss of some of the agricultural labor force, increasing difficulty for the elderly in agricultural production, and, thereby, reducing the productivity of agricultural labor and land productivity, and increasing the willingness to rent out transfer land [62], which has a positive impact on the development of the land transfer market and farmers' land transfer behavior. Changes in the scale of land operation further lead to changes in capital input per mu. For example, large-scale operation can help improve the problem arising from land fragmentation and make it easier to introduce advanced mechanical production technology [63]. Nonetheless, under the current land property rights system in China, the property rights attributed and the stability of self-owned farmland and leased farmland are different, which may change farmers' investment decisions [64,65].

In fact, the allocation of family agricultural production factors is intrinsically linked. According to the theoretical framework of the New Labor Migration Economics, households continue to reorganize and allocate the various production factors (land, labor, capital) within families to optimize production decisions [66]. Rational families in rural China realize the reallocation of household production factors among different production activities through land transfer, labor mobility, and credit acquisition [67,68], in order to maximize household utility. Therefore, theoretically, farmers allocation of various production factors is jointly determined by their joint decision-making behavior; that is, there is a correlation between families' inputs of various factors [11,69].

The NRPS is an external input fund, which triggers the reallocation and linkage effect of various agricultural production factors in families. For example, people who receive NRPS pension payments are more likely to purchase agricultural production tools as labor

substitutes, which in turn indirectly affects the allocation of land resources and the investment of agricultural production [62,70]. It can be seen that the NRPS affects the joint decision-making of agricultural production factor inputs through various pathways. However, the final impact of the NRPS depends upon the degree and direction of the impact through each pathway. A detailed theoretical framework is shown in Figure 2.

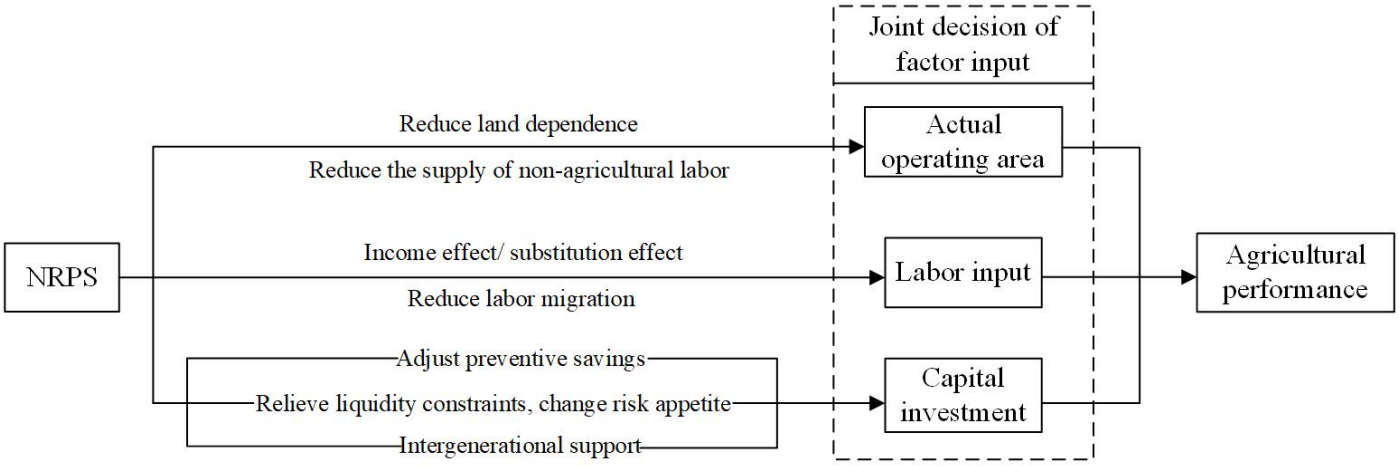


Figure 2. Theoretical framework.

4. Data, Variables and Modelling

4.1. Data

The data used in this study came from the CHARLS carried out by Peking University. This project collected a set of high-quality micro-data representing families and individuals aged 45 and over in China. CHARLS conducted a survey in 150 counties and 450 communities (villages) in 28 provinces (autonomous regions and municipalities) in 2011, 2013, 2015, and 2018, respectively. The national baseline survey was carried out in 2011, covering 17,000 people in about 10,000 households. By the time the nationwide follow-up was completed in 2018, the sample covered 19,000 respondents in a total of 12,400 households. The CHARLS questionnaire design draws on international experience, including the American Health and Retirement Survey (AHRS), English Longitudinal Study of Aging (ELSA), and the Survey of Health and Retirement in Europe (SHARE), etc. Multi-stage sampling was used for the project, with the PPS sampling method in both the county/district and village sampling stages. The CHARLS questionnaire includes personal basic information, family structure and economic support, health status, physical measurement, medical service utilization and medical insurance, work, retirement and pension, income, consumption, assets, and basic information about community, which provide good data support for this study. It should be pointed out that although the sample selection of CHARLS is "Chinese households of middle-aged and elderly people aged 45 years and above", the information of all household members is recorded for each interviewee.

In terms of data cleaning, first, the middle-aged and elderly individual data were matched with family-related information, and then only the samples in rural areas were retained, and the missing samples of key variables were eliminated. Finally, a four-unbalanced panel database was generated with a total of 40,964 observations for middle-aged and elderly individuals; the sample size was 30,200 when a balanced panel was required, as described below. Due to the lack of control variables, the actual sample size in the model could be further reduced, as reported in the regression results.

4.2. Variables

The dependent variable of this study, agricultural production input, includes land, labor, and capital. Specifically, land input is characterized by the actual operating area of

the family, and labor input is characterized by the hours of labor input in the families' agricultural production; capital input involves the total capital investment represented by the prices of various types of agricultural material, hired labor costs, land rent, and rental machinery costs related to agricultural production.

Although we are concerned about the impact of NRPS pension payment on agricultural production, if an individual is in the NRPS contribution period, there may be an indefinite impact on agricultural production by strengthening household mobility constraints. Thereby, we generated key independent variables into three classification variables, namely "uninsured", "payment period", and "pension receipt".

To avoid biased regression results, several control variables that may affect household agricultural production were introduced in the econometric model. The individual characteristics of the head of household, i.e., the decision maker of household activities, can significantly affect the decision-making of household agricultural production [1]. We, therefore, added the head-of-household variables: gender, age, health, education, and marital status. Family characteristics usually impose constraints on agricultural production objectively [71], so we added variables, such as the proportion of labor force (18–60 permanent population), the area of contracted land, agricultural fixed assets, family size, annual income, grain subsidies, and medical insurance. In addition, the topographic condition of the village is also an important factor affecting agricultural production [72].

The descriptive statistics for each variable under different insurance states are shown in Table 1. The variables relating to the amount of money in different years were deflated using the rural PCI index. It can be seen that there are significant indigenous differences in the head-of-household characteristics and the family characteristics. For example, the heads of households in the pension receipt group are generally older and less educated; the payment period group has a higher value of agricultural fixed assets and a higher proportion of labor force; and the uninsured group obtains the least agricultural subsidies. In terms of dependent variables, the actual operating area of the payment period group is generally larger, and the pension receipt group has the least labor input and capital investment. However, the above description can only give relatively limited information from the mean, and the specific impact results rely on the more rigorous statistical inferences below.

Table 1. The definitions and descriptive statistics of the data.

Variable	Definition	Observation	Uninsured		Payment Period		Pension Receipt	
			Mean	SD	Mean	SD	Mean	SD
Actual Operating Area	Household contracted land area plus rent-in land area minus rent-out land area (mu)	35,533	6.462	16.841	9.065	30.916	5.211	9.219
Labor Input	Input time of labor force in agricultural production (hundred hours)	39,369	12.418	16.004	13.633	15.855	10.268	14.098
Capital Input	Agricultural cost (ten thousand yuan)	37,517	6.500	174.860	6.357	169.957	3.794	131.773
Gender of household head	Male = 1; Female = 0	40,964	0.488	0.500	0.481	0.500	0.467	0.499
Age of household head	Actual age	40,247	59.503	10.534	52.881	6.163	68.075	7.486

Education of household head	Years of education (years)	40,954	2.985	1.771	3.365	1.735	2.412	1.600
Chronic disease of household head	Having a chronic disease = 1; otherwise = 0	40,918	0.492	0.500	0.239	0.426	0.245	0.430
Medical Insurance of household head	Having medical insurance = 1; otherwise = 0	40,902	0.934	0.248	0.974	0.160	0.962	0.191
Family population	Number of family members	40,462	3.461	1.856	3.508	1.601	3.040	1.695
Labor Percent	18–60 resident population percentage	40,964	0.716	0.395	0.854	0.317	0.843	0.333
Agricultural Fixed Assets	Present value of family Farming fixed assets (ten thousand yuan)	40,962	0.085	0.509	0.190	1.328	0.067	0.742
Agricultural subsidies	Agricultural subsidies received last year (ten thousand yuan)	33,644	0.053	0.103	0.091	1.590	0.056	0.099
Income	Total household income last year (ten thousand yuan)	35,872	2.963	41.037	2.548	10.881	1.453	3.346
Village terrain	Village terrain is plain (=1), hill (=2), mountainous region (=3), plateau (=4), basin (=5)	40,788	2.126	0.984	2.071	0.974	2.079	0.954

4.3. Modelling

4.3.1. Benchmark Regression: Seemingly Unrelated Regression Estimation

In the quantitative study of the impact of the NRPS on farmer input of agricultural production factors, land, labor and capital factors can be estimated separately by a single equation, or the three equations can be jointly estimated at the same time to improve the estimation efficiency, i.e., "System Estimation". Since there may be unobservable factors that simultaneously affect the input of land, labor, and capital [11], indicating that there is a correlation between the disturbance terms of the three equations, we developed the following Seemingly Unrelated Regression Estimation (SUR):

$$\begin{cases} OperatingArea_{it} = \alpha_i + \beta_1 InsuredStatus_{it} + \gamma C_{it} + \mu_t + \nu_t + \varepsilon_{it} \\ LaborInput_{it} = \alpha_i + \beta_2 InsuredStatus_{it} + \gamma C_{it} + \mu_t + \nu_t + \varepsilon_{it} \\ AgriCost_{it} = \alpha_i + \beta_3 InsuredStatus_{it} + \gamma C_{it} + \mu_t + \nu_t + \varepsilon_{it} \end{cases} \quad (1)$$

where the actual operating land area, labor input, and capital investment of the family agricultural production of the rural resident i in the t period are denoted, respectively, by $OperatingArea_{it}$, $LaborInput_{it}$, and $AgriCost_{it}$. The status of the rural resident i participating in the NRPS in the t period is represented by $InsuredStatus_{it}$. The control variables are denoted by C_{it}, the constant term is denoted by α_i, and the fixed effect of the year and the province are, respectively, represented by μ_t and ν_t. The parameters to be estimated are denoted by β and γ, and the disturbance term is represented by ε_{it}. Assuming that there is a simultaneous correlation between the disturbance terms of the three equations:

$$\mathrm{E}(\varepsilon_{it}\varepsilon_{js}) = \begin{cases} \sigma_{ij}, t = s \\ 0, t \neq s \end{cases} \quad (2)$$

After the SUR estimation of the multi-equation system, the null hypothesis "H_0: there are no simultaneous correlations between the disturbance terms of the equations", that is, "H_0: Σ is a diagonal matrix", so the following LM statistic is used:

$$\lambda_{LM} = T\Sigma_{i=2}^{n}\Sigma_{j=1}^{i-1}r_{ij}^{2} \xrightarrow{d} \chi^{2}(n(n-1)/2) \quad (3)$$

where the synchronous correlation coefficient between the disturbance term ε_i and ε_j calculated according to the residual term is denoted by $r_{ij} = \frac{\hat{\sigma}_{ij}}{\sqrt{\hat{\sigma}_{ii}\hat{\sigma}_{jj}}}$, and the sum of the squares of terms below the main diagonal of the synchronous correlation coefficient matrix for the same period is denoted by $\Sigma_{i=2}^{n}\Sigma_{j=1}^{i-1}r_{ij}^{2}$.

4.3.2. Endogeneity Treatment: Conditional Mixed Process

Even if SUR can perform multi-equation joint estimation to improve the estimation efficiency, the state of individual participation in the NRPS may be related to a disturbance term; this could be the estimation error caused by uncontrolled climatic and environmental factors, the heterogeneity of individual investment preferences, or even the change in the allocation of household production factors in agricultural production decisions that may be transmitted to NRPS participation decision-making through some unobservable channel. To alleviate the above endogenous problems, this study used the instrumental variable method to further process the independent variables; it also used the instrumental variables to distinguish the parts of the endogenous variables that were not related to the disturbance term, and then used these parts to obtain a consistent estimation. Considering that the focus of this study is on the agricultural productive effect of NRPS pensions, and it is usually difficult to estimate three-category variables using the instrumental variable method (IV), we only examined whether individuals receive NRPS pensions in IV estimation. The estimation method used the Conditional Mixed Process (CMP) proposed by Roodman [73], which is based on SUR and the maximum likelihood estimation, and constructs recursive equations to realize the estimation of a multi-stage regression model. The model is set as follows:

$$\begin{cases} PenReceipt_{it} = \alpha_i + \beta_4 IV_{it} + \gamma C_{it} + \mu_t + \nu_t + \varepsilon_{it} \\ OperatingArea_{it} = \alpha_i + \beta_5 PenReceipt_{it} + \gamma C_{it} + \mu_t + \nu_t + \varepsilon_{it} \\ LaborInput_{it} = \alpha_i + \beta_6 PenReceipt_{it} + \gamma C_{it} + \mu_t + \nu_t + \varepsilon_{it} \\ AgriCost_{it} = \alpha_i + \beta_7 PenReceipt_{it} + \gamma C_{it} + \mu_t + \nu_t + \varepsilon_{it} \end{cases} \quad (4)$$

where the situation of the rural resident i receiving the NRPS pension in the t period is denoted by $PenReceipt_{it}$ and the instrumental variable of whether to receive pension is represented by IV_{it}.

4.3.3. Robustness Test: RDD–DID

To examine the robustness of the regression results, we refer to concepts of related research [6] and use the idea of Differences-in-Differences (DID) to excavate the treatment effect of receiving pensions. However, participation in the NRPS is independently determined by rural residents, and individuals who apply for the NRPS may be quite different from other individuals in terms of unobservable characteristics. Meanwhile, the NRPS requires that the minimum age for receiving pensions is 60 years old, resulting in a significant difference in the probability of receiving pensions around the age of 60, forming a cutoff point. Hence, the time for rural residents to receive pensions is stipulated by the policy, which is relatively exogenous compared with individuals. Therefore, we referred to the RDD–DID method produced by Persson to identify the impact of NRPS pensions on agricultural production by using differences in age and time [74]. The models were developed as follows:

$$OperatingArea_{it} = \alpha_i + \beta_8 Age[d \geq 60] + \beta_9 G_i \times Age[d \geq 60] + f(d-60) + Age[d \geq 60] \times f(d-60) + \gamma C_{it} + \delta_t + \mu_t + \nu_t + \varepsilon_{it} \quad (5)$$

$$LaborInput_{it} = \alpha_i + \beta_{10} Age[d \geq 60] + \beta_{11} G_i \times Age[d \geq 60] + f(d-60) + Age[d \geq 60] \times f(d-60) + \gamma C_{it} + \delta_t + \mu_t + \nu_t + \varepsilon_{it} \quad (6)$$

$$AgriCost_{it} = \alpha_i + \beta_{12} Age[d \geq 60] + \beta_{13} G_i \times Age[d \geq 60] + f(d-60) + Age[d \geq 60] \times f(d-60) + \gamma C_{it} + \delta_t + \mu_t + \nu_t + \varepsilon_{it} \quad (7)$$

where the individual age is denoted by d, which is the driving variable of RDD. The marker variable is denoted by $Age[d \geq 60]$—if the individual age is 60 years old or above, a value of 1 is assigned, otherwise the value equals 0. The group variable of whether to receive NRPS pension is represented by G_i, the value of which equals 1 when receiving a pension in that year, and 0 otherwise. The local polynomial function for the driving variable is denoted by $f(d-60)$. We use quadratic polynomials in recognition and allow them to have different shapes on either side of the breakpoint. The individual fixed effect of farmers is denoted by δ_t. The coefficients we are concerned about are β_9, β_{11}, and β_{13}, which characterize the effect of NRPS pensions on agricultural production inputs.

5. Results

5.1. Benchmark Regression

The estimation results for SUR are reported in Table 2. The Breusch–Pagan test rejects the null hypothesis that the disturbance terms of each equation are independent at the 1% level; systematic estimation using SUR can improve the estimation efficiency. The regression results with the uninsured as the control group show that participation in the NRPS or the pension reception of rural residents significantly reduces a household's actual operating area and capital investment, and increases labor input, at most at the 5% level. This evidence provides a preliminary indication that the NRPS may have changed China's factor allocation of agricultural production in the past. From the perspective of the value of the estimated coefficient, although the NRPS helps to realize the replacement of land security by institutional guarantees, farmers are still limited by liquidity constraints and livelihood dependence during the payment period, and this substitution role is not fully played out. Therefore, the households receiving pensions reduce more actual operating areas than the insured households in the payment period. Meanwhile, when farmers engage in agricultural production under specific resource and technical constraints, in order to maximize profits, they adjust production in light of interests to optimize the factor allocation [75]. The payment to the NRPS allows these farmers to adopt a capital-saving production strategy, which means expanding labor inputs and reducing land and capital inputs, in an attempt to maximize agricultural output, while minimizing capital input. However, the results show that farmers who receive pensions also tend to adopt a similar production strategy. Two possible explanations are as follows; firstly, pensions provide a certain material guarantee to the elderly, improve the health status of the elderly, and, thus, increase the intensity of agricultural labor [16]. Secondly, pensions reduce the probability of off-farm employment or part-time work by the elderly after retirement, and this part of time is used for their own agricultural production activities. Our findings support Shi and Chang [1,28,29], who also believe that pension schemes will reduce the size of family farming operations, but contradict the conclusions of Zheng and Shu [6,32], who believe that the NRPS will increase their own agricultural labor supply and capital input. These differences may be attributed to the introduction of the multi-period farmer survey data and the joint decision-making equation, which alleviate endogenous problems and improve estimation efficiency. Moreover, Zheng may obscure the mechanism by using county data [6]. For example, families receiving the NRPS pension lease their land to third-

party operators, who increase agricultural investment after realizing large-scale operation. However, these impacts are indirectly caused, rather than the direct effects of NRPS on household production.

As for the characteristics of the household head, male household heads invest more agricultural production factors than female household heads, which stems from men's stronger risk tolerance [76]. The age of the head of household significantly reduces the input of various agricultural factors, which is related to the risk aversion and physical fitness in the elderly. The education level of household heads has a significant and negative influence on the actual operating area and labor input of households because human capital contributes to the development of non-farm economic activities. The deterioration in the health of household heads significantly reduces labor input and increases capital investment to replace, which is in line with logic. Householders' medical insurance may optimize household human capital, strengthen risk preference, and significantly increase investment in agricultural production. In terms of family characteristics, the number of family members significantly reduces the actual operating area, but significantly increases labor input. A probable explanation is that CHARLS mainly collects data from middle-aged and elderly families aged 45 and above; the increase in family members means that the family-care burden of decision makers increases, which reduces the actual operating area to a certain extent [3]. The crowding out of non-agricultural employment or part-time activities by family care also allows farmers to spend more spare time on agricultural production, while more family members can contribute to family farming. The role of agricultural fixed assets and agricultural subsidies in promoting factor inputs is consistent with the conclusions of the relevant literature [70,77]. The increase in household income relaxes the constraints on household mobility, encourages farmers to expand their operating area, and reduces the input of their own agricultural production labor in the form of additional capital investment. It should be noted that due to the endogeneity of some control variables and the focus of this study on the agricultural production effect of the NRPS, the regression results for the control variables are not explained in detail here.

Table 2. Benchmark regression results.

	(1)	(2)	(3)
	Operating Area	**Labor Input**	**Capital Input**
	NRPS Participation (Control Group: Uninsured)		
Payment period	−1.069 ***	2.884 ***	−0.105 ***
	(0.271)	(0.409)	(0.016)
Pension receipt	−1.596 **	1.994 ***	−0.096 ***
	(0.716)	(0.443)	(0.017)
Gender of household head	0.899 *	1.387 ***	0.030 **
	(0.503)	(0.312)	(0.012)
Age of household head	−0.167 ***	−0.253 ***	−0.004 ***
	(0.035)	(0.022)	(0.001)
Education of household head	−0.405 ***	−0.659 ***	−0.005
	(0.149)	(0.092)	(0.004)
Chronic disease of household head	0.760	−1.409 ***	0.054 ***
	(0.510)	(0.316)	(0.012)
Medical Insurance of household head	0.095	1.391	0.094 ***
	(1.529)	(0.946)	(0.036)
Family population	−0.405 ***	0.405 ***	−0.004
	(0.155)	(0.096)	(0.004)
Labor percent	0.110	0.618	−0.017
	(0.722)	(0.447)	(0.017)
Agricultural fixed assets	3.622 ***	1.025 ***	0.137 ***
	(0.413)	(0.256)	(0.010)
Agricultural subsidies	52.678 ***	−0.668	0.692 ***
	(1.788)	(1.107)	(0.042)
Income	0.637 ***	−0.319 ***	0.014 ***
	(0.043)	(0.027)	(0.001)

Constant	11.870 ***	23.586 ***	0.430 ***
	(2.859)	(1.770)	(0.068)
Village Terrain	Yes	Yes	Yes
Province fixed effect	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes
N	32542	32542	32542
R^2	0.348	0.055	0.240
Chi^2	1510.07 ***	872.31 ***	1069.11 ***
Breusch–Pagan test		441.782 ***	

Note: ***, ** and * denote significant at 1%, 5%, and 10% level, respectively; standard errors are presented in parentheses.

5.2. Endogenous Treatment

Referring to relevant studies, we find two appropriate instrumental variables for "whether to receive pension", namely whether the individual age reaches 60 years old [10] and whether the village implements the NRPS [4]. These two instrumental variables represent the threshold requirements for region and individual age, respectively, and are relatively exogenous for the dependent variable.

The regression results for IV estimation using CMP are reported in Table 3. The first-stage estimation shows that both the two instrumental variables have a significant and positive correlation with pension receipt at the level of 1%. The residual correlation coefficient of the first-stage equation and the land and capital factor input equations pass the test, indicating that endogenous treatment is appropriate, while the labor input equation fails to pass the correlation test. Although the coefficients and significance of the regression results differ from the benchmark regression, the direction of influence is consistent with the benchmark regression, which demonstrates that the estimation results are still robust after alleviating the endogenous problem of the independent variables in the SUR model.

Table 3. IV estimation based on CMP.

	(1)	**(2)**	**(3)**
	Operating Area	**Labor Input**	**Capital Input**
Pension receipt	−1.989 ***	1.675 *	−0.115 ***
	(0.690)	(0.968)	(0.194)
Constant	9.283 ***	29.490 ***	0.204 ***
	(2.353)	(2.026)	(0.056)
Household head characteristics	Yes	Yes	Yes
Family characteristics	Yes	Yes	Yes
Village terrain	Yes	Yes	Yes
Province fixed effect	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes
The first stage estimation		Pension receipt	
Whether to carry out NRPS in this village		0.855 *** (0.088)	
The individual is older than 60 years		2.669 *** (0.028)	
Residual Correlation Test	0.070 ***	−0.056	0.120 ***
	(0.011)	(0.048)	(0.017)
N		34,084	
Log likelihood		−103,600.98	
Wald Chi^2		484.38 ***	

Note: *** and * denote significant at 1% and 10% level, respectively; standard errors are presented in parentheses.

5.3. Robustness Test

5.3.1. Replace Key Independent Variable

Since the amount of an NRPS pension partly depends on the level of insurance contributions, it is difficult for pension receipt, as an independent variable, to reflect the amount of pension, which may have a differentiated impact on agricultural production. Therefore, to verify the robustness of the previous regression results, this study first used the pension amount as an alternative variable to re-regress the model. The results are shown in Table 4.

Table 4. Robustness test: Replacing key independent variable.

	(1)	(2)	(3)
	Operating Area	**Labor Input**	**Capital Input**
The amount of NRPS pension	−0.009 ***	0.001 **	−0.000 *
	(0.003)	(0.001)	(0.000)
Constant	8.189 **	29.715 ***	0.170 ***
	(3.315)	(2.128)	(0.066)
Household head characteristics	Yes	Yes	Yes
Family characteristics	Yes	Yes	Yes
Village terrain	Yes	Yes	Yes
Province fixed effect	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes
N	19662	19662	19662
R^2	0.239	0.069	0.133
Chi^2	2373.80 ***	563.31 ***	1160.53 ***
Breusch–Pagan test		239.880 ***	

Note: ***, ** and * denote significant at 1%, 5%, and 10% level, respectively; standard errors are presented in parentheses.

It can be seen from Table 4 that with the increase in pension amount, the actual operating area and capital investment of farmers significantly decrease, and labor input increases significantly, which generally aligns with the results above.

5.3.2. Adjust the Estimation Method

To further eliminate the heterogeneity of unobservable characteristics between pensioners and non-pensioners, this study introduces the idea of regression discontinuity design and quasi-natural experiment, and refers to the RDD–DID method proposed by Persson [74], using the differences in age and time to identify the impact of NRPS pensions on agricultural production. An important prerequisite for using the RDD–DID method is to ensure that there is no systematic difference between the treated and control groups before receiving pensions. Specifically, we used the Event Study to test the parallel trend; that is, we added the relative year variable of pension receiving to the time-varying DID model. We present the dynamic effect of pension receipt between different years through intuitive graphing.

As can be seen in Figure 2, there is no significant difference between the experimental group and the control group before receiving pensions, while after receiving pensions, the agricultural production effect of pensions gradually appears. Specifically, Figure 3a,c show that the impact of pensions on operating area and capital investment presents a significantly negative causal relationship after receiving pensions, and the impact trend increases first and then weakens. Figure 3b indicates that the impact of pensions on labor input shows a significant and positive causal relationship after receiving pensions, and the impact trend gradually weakens. Hence, the parallel trend hypothesis of the time-varying DID model is generally satisfied in this study.

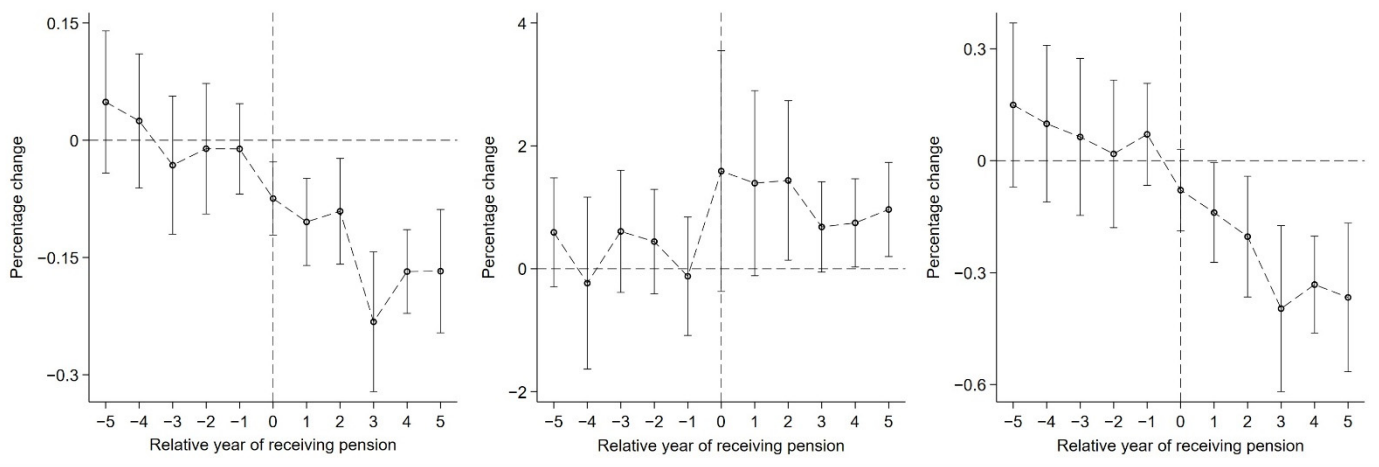


Figure 3. Parallel trend testing.

Fuzzy Regression Discontinuity (FRD) was then used and the bandwidth set to 3 years old. The treatment effect estimated by the RDD for the control group is subtracted from that of the treated group, to finally obtain the real treatment effect, the results for which are shown in Table 5.

Table 5. Robustness test: Adjusting the estimation method.

	(1)	(2)	(3)
	Operating Area	**Labor Input**	**Capital Input**
RDD * Diff-in-Diff	−0.119 **	1.321 **	−0.287 ***
	(0.050)	(0.614)	(0.084)
Constant	5.762 ***	33.923 ***	0.981 **
	(1.921)	(7.538)	(0.436)
Household head characteristics	Yes	Yes	Yes
Family characteristics	Yes	Yes	Yes
Village terrain	Yes	Yes	Yes
Province fixed effect	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes
N	5982	6630	5994
R^2	0.986	0.874	0.983

Note: ***, ** and * denote significant at 1%, 5%, and 10% level, respectively; standard errors are presented in parentheses.

The results demonstrate that the estimated coefficient of the real treatment effect RDD * Diff-in-Diff has a significantly negative impact on the actual operating area and a positive influence on labor input at the level of 5%, respectively, and significantly decreases capital investment at the level of 1%. This means that the robustness of the above regression results is confirmed by excluding the unobservable differences between the treated group and control group using the concepts of regression discontinuity and quasi-natural experiment.

5.4. Heterogeneity Analysis

Several research reports found gender differences in the economic effects of pensions. For example, Duflo found that elderly women receiving pensions had a significant improvement on the health and nutritional status of their granddaughters [13]. Li argued that elderly men receiving pensions could reduce the time spent on farming, increase the care for grandchildren, and the farming time of adult children, while the pensions of elderly women could only reduce their dependence on their offspring [4]. Xie further pointed out that men's pensions were more conducive to increasing land productivity [76]. The underlying logic is that there may be differences in preferences and uses of pensions between elderly men and elderly women, so it is of great significance to examine the gender differences in the agricultural production effect of the NRPS pensions for policy evaluation and adjustment. The regression results based on the heterogeneity of different gender effects are shown in Table 6.

Table 6. Estimation results for NRPS under gender heterogeneity.

	Male			**Female**		
	(1) Operating Area	**(2) Labor Input**	**(3) Capital Input**	**(4) Operating Area**	**(5) Labor Input**	**(6) Capital Input**
Insured Status (Reference Group: Uninsured)						
Payment period	−2.808 ***	3.427 ***	−0.094 ***	−0.769 *	2.200 ***	−0.114 ***
	(0.920)	(1.114)	(0.023)	(0.420)	(0.770)	(0.022)
Pension receipt	−1.777 *	2.266 **	−0.072 ***	−0.762	1.122 *	−0.115 ***
	(0.979)	(0.966)	(0.024)	(1.108)	(0.645)	(0.025)
Constant	16.350 ***	23.886 ***	0.868 ***	12.501 ***	24.740 ***	0.725 ***
	(4.412)	(3.782)	(0.191)	(4.364)	(3.476)	(0.172)
Head of household characteristics	Yes	Yes	Yes	Yes	Yes	Yes
Family characteristics	Yes	Yes	Yes	Yes	Yes	Yes
Terrain	Yes	Yes	Yes	Yes	Yes	Yes
Province fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Sample size	15962	15962	15962	16580	16580	16580
R^2	0.226	0.063	0.181	0.192	0.062	0.182
Chi^2	765.89 ***	175.14 ***	578.37 ***	645.93 ***	179.45 ***	607.77 ***
Breusch–Pagan test	367.643 ***			314.655 ***		

Note: ***, ** and * denote significant at 1%, 5%, and 10% level, respectively; standard errors are presented in parentheses.

The agricultural production effects of elderly men participating in the NRPS are presented in columns 1–3 of Table 6, and the agricultural production effects of elderly women participating in the NRPS are shown in columns 4–6. According to the comprehensive regression coefficient and significance, male participation in NRPS has a greater impact on reducing the actual operating area of households and increasing labor input because males may be more willing to rent out land and invest in labor. Female participation in the NRPS has a greater impact on reducing the investment in household agricultural production, possibly because women show a stronger risk aversion to investment, and the pensions of elderly women are more likely to be used for household care and expenditures, such as nutrition, education, etc.

5.5. Further Discussion: The Impact of NRPS Pensions on Agricultural Productivity

The above research results generally confirm that the NRPS pension reduces the actual operating area of the family, increases the labor input, and reduces the investment in agricultural production. In light of the "Structure–Conduct–Performance" analysis paradigm proposed by Mason and Bain, the implementation of the NRPS further affects agricultural performance by changing the allocation of agricultural production factors in rural households. Therefore, we intend to explore further how the NRPS affects household agricultural production efficiency. Agricultural production efficiency mainly includes labor productivity, land productivity, and technological efficiency. Firstly, the ratio of the annual agricultural output value to labor input was taken as the labor productivity, representing the agricultural output value per unit time of rural workers. Secondly, the ratio of the annual agricultural output value to the actual operating area was used as the land productivity, indicating the economic benefits of land use. Finally, the panel Stochastic Frontier Approach was used to estimate the technical efficiency of agricultural production and the Cobb–Douglas production function was selected to develop a model to measure the technical efficiency. The inefficient disturbance term was set to conform to the truncated semi-normal distribution, and the technical efficiency of household agricultural production was estimated, reflecting the producer's ability to achieve the theoretical optimal output by using the existing technologies. After calculating the three types of production efficiency, the RDD–DID method was used to estimate the impact of pension on various types of production efficiency. The estimated results are shown in Table 7.

Table 7. The regression results for NRPS pensions affecting agricultural productivity.

	(1) Labor Productivity	**(2) Land Productivity**	**(3) Technical Efficiency**
RDD * Diff-in-Diff	−0.081 ***	0.070 **	0.002 **
	(0.018)	(0.032)	(0.001)
Constant	9.085 ***	11.171 ***	0.635 ***
	(2.184)	(3.029)	(0.108)
Household head characteristics	Yes	Yes	Yes
Family characteristics	Yes	Yes	Yes
Village terrain	Yes	Yes	Yes
Province fixed effect	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes
N	5784	5739	5781
R^2	0.988	0.967	0.986

Note: ***, ** and * denote significant at 1%, 5%, and 10% level, respectively; robust standard errors are presented in parentheses.

As shown in columns 1–2 of Table 7, pensions significantly reduce labor productivity and increase land productivity, which is in accordance with the expectation of the results above. The implementation of the NRPS makes rural households tend to adopt labor-expansion/capital-saving agricultural production strategies. Although agricultural output per unit area is improved, this is at the expense of the decline of labor productivity. The results in column 3 show that pensions significantly improve technical efficiency, meaning that receiving pensions improves a farmer's ability to reach the potential frontier of agricultural production under the existing technical constraints. A probable explanation may be that families receiving pensions reduce the number of employees and alleviate the problem of slacking of hired labor. Meanwhile, pensions also help to increase household nutrition expenditure and improve the health of labor, thereby enhancing agricultural management ability. Our findings on land productivity and technological efficiency are

consistent with empirical evidence from South Africa and China [27,76], and we propose for the first time that pensions reduce the productivity of domestic agricultural labor.

6. Conclusions and Policy Implications

How should China respond to the problem of agricultural production in the process of rapid aging? This study provides several ideas from the perspective of social pensions. Firstly, the theoretical clues of the NRPS pension changing the allocation of production factors of rural households and the common decision-making among various factors were elaborated. Secondly, based on the CHARLS panel data of four rounds (2011, 2013, 2015, 2018), this study employed the methods of SUR and RDD–DID to test the impact of the NRPS on agricultural production, including its impact on agricultural production factor inputs and agricultural production efficiency. The empirical results show that NRPS pensions reduce the household operating area by 1.99 mu and agricultural investment by 1150 yuan, while increasing the labor time of their own agricultural production by 168 h; moreover, farmers in the payment period have a similar impact. This demonstrates that the NRPS encourages middle-aged and elderly families to rent out land and adopt the production strategy of "labor expansion/capital saving". On the one hand, this evidence means that the NRPS may stimulate the continuous development of China's rural land-leasing market, which is manifested in the fact that insured middle-aged and elderly families prefer to reduce operating area and rent out part of the land that they are unwilling to operate. The inflow of this considerable amount of land resource into the market may induce the emergence of large-scale business entities, thus contributing to the modernization of agricultural production. On the other hand, labor expansion/capital saving production strategies may hinder the process of agricultural mechanization, because insured farmer families are willing and able to pay for their own agricultural production, rather than renting agricultural machinery for production. Farmers may also reduce agricultural capital investment and increase labor input, which may also have implications for reducing the application of chemical fertilizers and pesticides, because they will have more time to adopt the application strategy of "multiple times and small amount" to promote green agricultural production. According to the gender of the insured, male participation in the NRPS has a greater impact on reducing the actual operating area of households and increasing labor input, while female participation in the NRPS has a greater effect on reducing the capital investment in a household's agricultural production. An interesting follow-up question is how the NRPS will affect agricultural performance by changing the allocation of agricultural production factors. This study further finds that receiving NRPS pensions significantly reduces the output value of agricultural labor per hour by 8.1 yuan, significantly increases the average output value per mu by 700 yuan and the technical efficiency by 0.2%. Hence, the implementation of the NRPS helps to increase household agricultural yields, although this is at the cost of declining labor productivity. In addition, receiving pensions also enhances a farmer's ability to reach the potential agricultural production frontiers under the constraints of existing technologies. It can be seen that although the NRPS leads to the downsizing of farming households, it also promotes intensive farming to improve land yields and narrow the gap between actual output and potential output; this proves that the NRPS promoted by the Chinese government can alleviate the production pressure imposed by the aging of the agricultural labor force on the agricultural sector to a certain extent, and that NRPS plays a positive role in agricultural production.

Based on the above research conclusions, we put forward the following suggestions. First, while studying the welfare effect of the NRPS in the future, its impact on agricultural production should also receive attention. Accurate assessment of the agricultural production effect of the NRPS cannot only provide new ideas for further research on the relationship between aging and agricultural production, but also provide theoretical support for policymakers in the continuous improvement of the NRPS. Secondly, our results provide evidence to suggest that the NRPS has considerable agricultural production potential, so

it is necessary to further encourage rural residents to participate in it, both for the purposes of old-age insurance and food security. Thirdly, the NRPS may cause households to reduce agricultural investment represented by employment expenditure, thereby it is particularly necessary to accelerate the development of the agricultural division of labor, including speeding up the development of agricultural mechanization and the development of agricultural productive services with high homogeneity, so as to ensure food production, while leaving the elderly out of agricultural management and improving the happiness of the elderly. Finally, governments should continue to support the development of large-scale and intensive agricultural producers, and efficiently absorb the cultivated land resources released by the NRPS through land leasing and other forms to facilitate the transformation of agricultural modernization.

Despite our great effort to analyze the agricultural production effects of the NRPS, several unresolved problems require further study and expansion. For example, limited to the model setting, we could not show the agricultural production input and performance for the NRPS payment period under the RDD–DID method and we only examined the agricultural production effect of NRPS pensions. Secondly, we regard farmers in the payment period as an indiscriminate group, but in fact, farmers can choose from a total of 12 payment levels of between 100 and 2000 yuan per year, and farmers can choose to pay annually or a one-time payment. The above differences may have a certain impact on agricultural production, but we were limited by the availability of data and could not investigate these. Thirdly, an exploration of those who lease the cultivated land from farmers who abandon their management through land leasing after participating in the NRPS, and the impact this cultivated land has on production efficiency, could help us understand whether the NRPS can sustainably support rural economic development.

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